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SERIE: HYDROGRAFI · BIND I

NR. 6. MARTIN KNUDSEN: CONTRIBUTION TO THE HYDROGRAPHY OF THE NORTH ATLANTIC OCEAN. (WITH 21 PLATES)

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
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CONTRIBUTION

TO

THE HYDROGRAPHY OF THE NORTH ATLANTIC OCEAN

BY

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(WITH 21 PLATES)

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Introduction.

In the year 1897 a series of determinations of the temperature and salinity of the surface-water together with gatherings of plankton were commenced on the Iceland and Greenland routes. These researches were carried out under the direction of Contreadmiral C. F. Wandel, and the results of the work of the first three years were published in: "Iagttagelser over Overfladevandets Temperatur, Saltholdighed og Plankton paa islandske og grønlandske Skibsrouter i 1897, 1898 og 1899". The work has been continued without interruption though with some retrenchments, and now in a somewhat extended form forms a part of the international hydrographic researches. Thus the material in hand is now covering almost a period of 8 years, and so it is to be expected, that a contingent annual periodicity may be shown already now. The hydrographic material of observation for 1900—1904 consists, as in the preceding years, of the temperature and the salinity of the surface-water together with a series of meteorological observations. As the latter are also sent to the Meteorological Institute they will not be published here, while all the determinations of temperature and salinity together with the dates of observation have been entered in the accompanying maps. These maps have been drawn by Miss Kirstine Smith, who has also done the calculations connected with the formation of means and mean deviations. It is an agreeable duty to say her my best thanks and also to thank the ship-owners, the captains and lieutenants through whose care the material has been provided.

Mean Values of the Temperature and the Salinity of the Surface Water.

The mailsteamer "Laura" has regularly made 8 voyages annually, and a review of the material has proyed, that the voyages have always taken place within the periods stated in the following table:

first voyage.....	18. January	—18. February
second —	8. March	— 2. April
third —	16. April	—17. May
fourth —	31. May	—25. June
fifth —	12. July	— 3. August
sixth —	18. August	—13. September
seventh —	27. September	— 1. November
eighth —	16. November	—13. December

The route which the "Laura" followed generally lies within the two lines drawn on the map, Pl. I. So of all the observations those have been taken out which occur between these lines, and only those are used for the formation of the mean values, which are noted in the following tables. The comparatively few observations, which have been taken from other ships between the two lines and between the periods mentioned in the above table, have, however, also been noted, for instance some of the observations from the Scotch and Danish seasonal cruises.

The determinations of salinity are made by chlorine titration, with application of different standard water. In the transition from one standard water to another comparative titrations of the standard water have been made, but not until in May 1901 the standard water VI, which was determined together with the constants, on which the hydrographic tables are based, was used, and afterwards the standard water has been derived herefrom. From May 1901 the hydrographic tables have been used to find the salinity of the amount of chlorine. Hereby the material of the salinities has become heterogeneous, which makes the following determinations of mean numbers for the 8 years somewhat uncertain. The comparative titrations of the different samples of standard water yield, however, a pretty good means to correct the titrations of the first years, so that they get comparable with those undertaken in the later years. Thus it has been proved, that the determinations of salinity, which were made before May 1901 must be corrected with $k \frac{A}{35{\cdot}00}$ ‰, A being the salinity found by the old determinations, while k has the following values:

For titrations from January 1897 till January 1899	.....	$k = -0{\cdot}13$ ‰
— — — — 1899 — May 1901	.....	$k = -0{\cdot}05$ ‰
— — after May 1901	.....	$k = 0{\cdot}00$ ‰

The material of observations has now been corrected with the above-mentioned values and then treated in the following way.

For each of the named 8 annual periods (voyages) the observations, which occur within two succeeding whole degrees of longitude have been compiled, and herefrom the mean values have been formed. As an instance may be mentioned that of the observations of salinity, which occur within the two named lines and the 3° and 4° meridians (W. of Greenwich), and which have been taken during the first voyage, a mean number has been formed for each of the eight years. Of the 8 mean numbers thus arrived at a mean number has again been formed, which proved to be 35·37. Thus this should mean that within the mentioned area the mean value of the salinity in January—February is 35·37. A mean value has thus been formed in a similar way for each of the areas, which are bordered by the two lines and every two meridians succeeding each other between 2° W and 18° W. Thus we get a whole series of mean numbers, of which each corresponds with a certain area and all refer to the first voyage (18. Jan.—18. Febr.). For each of the other voyages a series of mean values have then been formed in the same way, so we get a table with two arguments, of which one is the place (defined by a certain area), and the other argument is the number of the voyage or the different months. For a single area, for instance the above-mentioned, the table thus states how the salinity has been on an average during each of the voyages. If then we form the mean number of the values noted for the different voyages, we get the mean number of the salinity in the area considered for the whole year. If, in the like way, we form the mean values for the rest of the areas and make a quite analogous calculation for the temperature of the surface water we get the table following on the next page.

The last column of the table contains an indication of the number of observations, on which each mean number is based. In all 1369 observations have been available. From the last column but one of the table we may see how great a deviation from the noted mean values of the salinities we may on an average expect on each single area.

It might perhaps be objected to the mentioned formation of mean numbers that the single voyages have not been of equal length, and that the same time has not elapsed between them, and that, therefore, they ought not to be of the same weight in the forming of the mean values for the year. It has also been tried to give the value for each single voyage a suitable weight, but the values found in this way were practically speaking not different from the above mentioned ones.

Table 1.

Indication of the area by the meridians	The mean value for the year of the surface temperature	The mean value for the year of the salinity	The mean deviation of a single observation of salinity from the noted means	Number of observations
2°— 3° W	9°·59	35·125 ‰	0.18 ‰	60
3°— 4° -	67	302 -	15 -	120
4°— 5° -	33	284 -	12 -	176
5°— 6° -	8°·72	235 -	10 -	194
6°— 7° -	16	203 -	09 -	139
7°— 8° -	21	229 -	07 -	66
8°— 9° -	54	250 -	08 -	70
9°—10° -	56	248 -	09 -	68
10°—11° -	75	254 -	06 -	53
11°—12° -	88	253 -	07 -	54
12°—13° -	93	249 -	08 -	58
13°—14° -	9°·02	254 -	06 -	52
14°—15° -	8°·97	250 -	06 -	61
15°—16° -	9°·11	234 -	05 -	66
16°—17° -	8°·92	224 -	07 -	60
17°—18° -	77	191 -	11 -	72

When the noted series of mean values for the year of the salinity are subtracted from those for each single voyage, we get the following table in which thus for each single area the deviation of the salinity from the mean value on each of the different voyages is indicated.

Table 2.

	2°—3° W	3°—4° W	4°—5° W	5°—6° W	6°—7° W	7°—8° W	8°—9° W	9°—10° W	10°—11° W	11°—12° W	12°—13° W	13°—14° W	14°—15° W	15°—16° W	16°—17° W	17°—18° W	3°—18° W
1st Voyage..	12	7	2	—3	—4	—1	2	—1	2	0	3	3	1	1	1	5	1·2
2nd — ..	—7	—5	4	6	—5	0	0	5	1	0	2	1	1	1	4	7	1·5
3rd — ..	—6	7	6	—1	2	—4	4	4	1	3	2	3	2	4	7	5	3·0
4th — ..	7	9	4	8	3	3	5	1	1	0	1.	—2	0	1	—3	—5	1·7
5th — ..	—4	—6	—1	3	5	1	1	0	0	1	0	—3	—2	—3	—4	—5	—0·9
6th — ..	—1	—1	—4	—4	0	—1	0	1	—6	—1	—2	0	—1	—2	—3	—5	—1·9
7th — ..	3	—7	—2	—9	—1	—1	—9	—10	—2	—4	—3	—1	—3	—2	—3	—4	—4·1
8th — ..	—4	—2	—9	1	—1	1	—2	—2	2	0	—4	—1	0	0	1	2	—0·9

From the series of numbers, which indicate the mean value of the salinity for the year, will be seen that the salinity between 2° and 3° W is the lowest, namely 35·13, which must be attributed to the fresher North Sea-water and the coast water from Scotland, which thus exercises its influence as far from the coast as to this area. Between 3° and 5° W the salinity is highest, namely about 35·29; here we thus have the kernel of the eastern part of the Gulfstream. Between 5° and 8° W the salinity is again somewhat lower, the cause of which is: partly and especially that the route approaches the east Icelandic polar current, partly that this area receives some fresh water from the Faroe islands. From 8° to 15° W the salinity only varies very little, namely from 35·248 to 35·254, that is only 0·006 ‰, and west of 15° the salinity again decreases, especially because the route is now so near Iceland, that the fresh coast water gets influence.

From the table of the deviation of the salinity from the mean value during each of the different voyages, we see that the deviations are generally very slight, namely only a few hundredths promille. Any complete regularity in the distribution of the signs is not found, especially not for the area, which

is lying between 2° and 3° W. As to this area the now positive, now negative deviations are explained by the fact that the supply of water from the North Sea and the shore water takes place irregularly and takes place during all seasons, driven to sea by the casual winds. As to the other areas the distribution of the signs is somewhat more regular, as during the first four voyages they are chiefly positive, and negative during the four last voyages. This is still clearer, when we gather all the areas between 3° W and 18° W and form the mean values of the deviations for all these different areas; then we get the last column of the table which shows plainly, that the water on the "Laura's" route has on an average its highest salinity during the third voyage, that is to say at the end of April and the beginning of May (0,030 ‰ over the annual mean value), and its lowest salinity during the seventh voyage, that is in the month of October (0.041 ‰ lower than the annual mean value). It must, however, be emphasized that the differences are not great, namely scarcely 0,07 ‰ between the maximum and minimum salinity. That the differences, even if they are slight, cannot be attributed to accidental circumstances, appears from the continuous variation in the last column of the table. Corresponding series of deviations for each of the years show all the maximum of salinity in spring and the minimum in autumn. Now if we only look at the most western areas, it seems as if both the maximum and the minimum salinities occur somewhat earlier in the year, the maximum salinity for the most western area being shifted from the third to the second voyage (from April to March) while the minimum salinity has been shifted from the seventh to the fifth voyage (from October to July). This may possibly be explained by the fact, that the river-water from Iceland serves to diminish the salinity earlier in the year than the diminution, which is owing to the Gulfstream itself. That this is true, at all events as to the most western area, is also confirmed by the mean deviations noted in Table 1, which as to this area amount to 0·11 ‰, which is greater than any of the other deviations occurring west of the Faroe islands. Here, near Iceland, as might be expected, we thus find comparatively great variations in the salinity. Still greater, however, are the variations between Scotland and the Faroe islands. For the most eastern area (2°—3° W) the mean deviation amounts to 0·18 ‰ on account on the frequent (and irregular) supply of North Sea water and shore water from Great Britain and Ireland. In the open sea, too, between Scotland and the Faroe islands, where we find the greatest salinities, the mean deviations are relatively great, namely 0·15 and 0,12 ‰, which must be considered as if we were here on or near the borders of the Atlantic water and the water of the Norwegian Sea. Even if the Gulfstream is passing between the Faroe islands and Scotland into the Norwegian Sea this streaming in is not as an ever progressing steady current. There are, on the contrary, currents to and fro, nay in all directions, so that now shore water and water from the Norwegian Sea is carried far across the Gulfstream, while now large parts are covered by water from the east Icelandic polar current. The result of all these currents is that the water has a mean speed towards the Norwegian Sea, but this speed is probably only a fraction of the speed of the really occurring currents, when not calculated with signs. As the very greatest part of the water, which the Norwegian Sea receives from the Atlantic ocean, passes in this way through the comparatively narrow strait between Scotland and the Faroe islands, this water consequently receives a mixture partly of water from the Norwegian Sea and shore water and partly of water from the east Icelandic polar current. This mixture does not occur steadily with equal amounts, but in jerks accordingly as the wind is leading the waters. So the waters in the upper layers of the eastern and the southern parts of the Norwegian Sea become heterogeneous, clouds or islands of less salt water are formed in water of higher salinity and vice versa, and the mean value of the salinity gets somewhat less than in the Atlantic water streaming in. So we may very well discern between the water in the northern part of the Atlantic ocean and the water in the southern and eastern (or central) part of the Norwegian Sea. The here mentioned struggle between the different waters above the Wywille Thompson ridge appears in the comparatively great variations of the salinity, which in Table 1 are expressed by the mean deviations 0·15 and 0·12 ‰ between 3° and 5° W.

In the waters between the Faroe islands and Iceland the mean deviations are only little. So here we find the very Atlantic water, which in comparison with the Norwegian Sea water excels by its homogenity from one place to the other and its slight variation in salinity from time to time. (See Table 2).

A consideration of the series of temperature in Table 1 proves, that the annual mean value of the temperature in the different places varies in a way analogous with the salinities. We see, that the most saline water has the highest temperature, 9°·7 in maximum value between 3° and 4° W. Between 6° W and 7° W the series of temperature has a minimum at the same place as the salinity on account of the nearness of the east Icelandic polar current. Between 7° and 12° W the temperature is rising pretty fairly from east towards west, in all 0°·7, while from 12°—17° W it is keeping almost constant. The cause of this rising of temperature between 7° and 12° W is, no doubt, that the route here diverges more and more from the east Icelandic polar current, while the effect of the latter cannot have any influence so far towards the south, west of the 12° meridian.

As to the temperature a table may be formed corresponding with Table 2. Such a table then would show the annual course of the temperature in the different places. We shall, however, prefer, to communicate the original table, in which the temperature was noted as a function with two arguments, namely the place and the number of voyage.

Table 3.

	2°—3° W	3°—4° W	4°—5° W	5°—6° W	6°—7° W	7°—8° W	8°—9° W	9°—10° W	10°—11° W	11°—12° W	12°—13° W	13°—14° W	14°—15° W	15°—16° W	16°—17° W	17°—18° W	2°—18° W
1st Voyage	7·5	7·8	**7·4**	**6·9**	6·4	6·7	7·3	6·8	7·2	7·5	7·5	7·3	**7·1**	7·7	7·6	**6·7**	7·2
2nd —	**6·5**	**7·0**	7·5	7·2	**6·3**	**6·1**	**6·9**	**6·7**	**7·1**	**7·2**	**7·2**	**7·1**	7·3	**7·5**	**6·5**	7·0	**6·9**
3rd —	7·5	8·1	8·3	7·5	7·0	7·3	7·5	7·9	7·9	7·6	7·6	7·8	7·9	8·1	7·7	7·5	7·7
4th —	10·0	10·7	10·2	9·8	8·7	9·3	9·0	9·4	9·2	9·5	9·9	9·5	9·5	9·5	9·3	9·6	9·6
5th —	11·9	12·0	**12·0**	**10·8**	**10·2**	**10·1**	**11·1**	**10·8**	**11·1**	**11·2**	**11·5**	**11·9**	**11·6**	11·6	11·3	**11·3**	11·6
6th —	**12·5**	**12·2**	11·7	10·8	10·1	9·7	10·1	10·8	10·9	11·0	10·7	11·9	11·4	**11·8**	**11·8**	**11·6**	11.2
7th —	11·3	10·6	9·9	9·1	9·0	8·8	8·8	8·5	8·9	9·1	9·3	9·0	9·2	9·1	9·1	8·8	9·3
8th —	9·6	8·9	7·6	7·7	7·6	7·8	7·6	7·6	7·8	8·0	7·9	7·7	7·8	7·6	7·8	7·7	7·9
	9·6	9·7	9·3	8·7	8·2	8·2	8·5	8·6	8·8	8·9	8·9	9·0	9·0	9·1	8·9	8·8	8.9
Difference between maximum and minimum temperature	6·0	5·2	4·6	3·9	3·9	4·0	4·2	4·1	4·0	4·0	4·3	4·8	4·5	4·3	5·3	4.9	4·4

The last series but one in this table is the series of temperature already given in Table 1. The last column shows the annual course of the temperature for the whole route taken in all. We see that the minimum temperature occurs about the second voyage, that is in March and the maximum temperature about August. The difference between the maximum and minimum temperatures amounts to 4°·4. From the temperatures noted for each area we see, that the conditions are essentially the same, the maximum temperature (blacker type) everywhere occurs at the same time, and so does the minimum temperature (blacker type). From the lowest series of numbers, which indicate the difference between the maximum and minimum temperature of each of the different areas, we see that the annual amplitude is greatest (6°·0) for the most eastern area, which is no doubt owing to the fact, that the measurings of temperature have been undertaken now in pure Atlantic water, now in water from the North Sea and the coasts, where we find more prominent extremes of temperature. It may seem peculiar, that the least difference is found near the Faroe islands, though the route there is lying nearest to the east Icelandic polar current, and the difference remains very slight until 12° W, that is as far west as the nearness of the east Icelandic polar current has influence on the temperatures. From the tables we see, that these

conditions are owing to the low maximum temperatures between 5° and 12° W, which according to the above stated is rather natural, if the Gulfstream on the whole is least prominent in summer and autumn.

It lies near to examine whether there is any essential change from one year to the other. Such an examination has also been made, the mean value of the salinities having been formed for each year. From the values found thus the series of salinity in Table 1 have been subtracted. Herefrom results the following table, which indicates in hundredths promille, how much greater the salinity has been in each year than the mean salinity. The years 1901 and 1902 are not included as we have too few observations for these years to give a reliable result. Nor could 1904 be included, as this year had not yet elapsed, when the calculation was made.

Table 4.

Year	2°—3° W	3°—4° W	4°—5° W	5°—6° W	6°—7° W	7°—8° W	8°—9° W	9°—10° W	10°—11° W	11°—12° W	12°—13° W	13°—14° W	14°—15° W	15°—16° W	16°—17° W	17°—18° W	3°—18° W
1897	2	1	2	—4	—3	1	—1	0	—4	2	—1	0	1	2	3	4	0·2
1898	4	6	3	—2	3	—5	1	—3	2	—4	3	3	7	2	4	—3	1·1
1899	6	1	2	0	5	1	0	0	2	—1	—4	0	0	1	0	—4	0·2
1900	—1	—9	3	1	4	4	0	4	6	3	4	0	—2	0	—1	4	1·4
1903	—9	3	—6	2	—3	—1	—2	—2	—2	—3	—2	—2	—2	—3	—3	—5	—2·1

From this table will be seen, that the changes to which the salinity is subject from year to year are exceedingly small. The numbers might seem to indicate, that the salinity in 1903 was on an average somewhat smaller than in the preceding years, but the table does not give any decisive communication in this respect as the systematical erors, which arose from the transition to new standard water and new chlorine constant could scarcely be corrected away, and in this table the remaining error with its whole value is included. It was different with Table 2, in which a remaining error of this sort can only be of very insignificant importance. To make a corresponding calculation for the temperatures does not lead to any result, as a far greater material of observation than that which has been at my disposal would be demanded, if the accidental distribution in the different seasons should not get to great an influence.

As the formation of means of the observations on the Laura-route seems to give good information about the seasonal changes in the salinity a similar formation has also been tried on the routes from N of Scotland to S of Greenland- From 1° W to 19° W all the observations of salinity lying between 59° N and 61° N have been used. From 19° W to 47° W the observations have been divided in two groups, one group containing the observations from the northern routes and the other one containing the observations from the southern routes. These two groups of areas are indicated by the lines drawn on the last map on Pl. XXI. A table corresponding to Table 2 has been formed in taking the areas lying between the lines mentioned above and between the meridians 1° W and 3° W, 3° W and 5° W and so on for each two degrees until the area between 45° W and 47° W. Of this table very little is to be seen and it should not be given in extenso here. If the mean salinities for the whole year are formed, we get the following table:

Table 5. Eastern areas between 1° W and 19° W.

	The area between 59° N and 61° N and the meridians:								
	1°—3° W	3°—5° W	5°—7° W	7°—9° W	9°—11° W	11°—13° W	13°—15° W	15°—17° W	17°—19° W
Mean value for the year of the salinity	35·16	35·28	35·28	35·33	35·32	35·32	35·28	35·26	35·29
Number of observations	87	306	118	78	67	44	50	55	39

Table 6. Western areas between 19° W and 47° W.

	The area between the meridians:													
	19°—21° W	21°—23° W	23°—25° W	25°—27° W	27°—29° W	29°—31° W	31°—33° W	33°—35° W	35°—37° W	37°—39° W	39°—41° W	41°—43° W	43°—45° W	45°—47° W
Mean value for the year of the salinity:														
From the northern areas	35·25	35·25	35·20	35·21	35·18	35·15	35·12	34·96	34·91	34·91	34·90	34·67	34·82	34·44
Number of observations	28	23	27	23	19	23	17	24	15	18	11	13	17	30
From the southern areas	35·25	35·21	35·25	35·18	35·14	35·15	35·06	34·97	34·98	34·88	34·82	34·74	34·69	34·58
Number of observations	15	22	22	21	27	25	20	24	22	34	32	26	29	23

From these tables will be seen, how the salinities are commonly changing from the eastern to the western part of the north Atlantic. The salinity has its maximum, 35·33 ‰, between 7° and 9° W. It decreases very slowly until 35° W, where the mean value is about 35·00 ‰ and from that point more rapidly towards about 34·50 ‰ at 47° W.

The differences between the salinities from the northern and southern areas are only small and do not show any real change in north—southerly direction.

The voyages taken in consideration here always have been made between April and November, and so the numbers given at the means for the whole year signify the means for these 7 months. If we take the means for each of these months separately, drawing the northern and southern as well as some of the areas in east—westerly direction together, we get the following table.

Table 7.

	Area between 59° N and 61° N or between the lines on Pl. XXI and the meridians:			
	3°—21° W	21°—33° W	33°—39° W	39°—45° W
April	35·30	35·19	35·00	34·77
May	35·35	35·19	35·00	34·77
June	35·31	36·17	34·96	34·79
July	35·31	35·18	34·93	34·76
August	35·30	35·08*	34·92	34·67*
September	35·26	35·20	34·83	34·81*
October	35·27	35·18	34·83	34·81*

On the eastern part of the route we have the same seasonal changes as discovered on the Scotland—Faroe—Icelands routes. The maximum of salinity occurs in May, the minimum in September. On the area between 21° and 33° W the variations during the 7 months is very small, when the mean value 35·08 ‰ for August is not taken in considerations. This value, as well as the others marked with *, signifies that very few observations have been at hand, and that they have been lying in the southern route only. The numbers from the next area 33°—39° W show a continuous variation with the ordinary maximum in spring and a minimum in summer. The last area 39°—45° W does not show any special regularity, of which follows, that regular seasonal changes do not occur in the polar current. This also is shown by the following table, which gives a comparison between the salinities in the northern and southern area between 45° and 47° W.

From Table 8 is seen, first that the salinities undergo considerable changes, next that these changes are not bound to the seasons to such an extent, that they can be deduced from the table with any certainty.

Table 8.

	April	May	June	July	August	September
Area between 45°—47° W and						
58°20′—59°40′ N (northern area)	34·47	34·62	34·67	34·50	34·18	34.84
or 56°40′—58°20′ N (southern area)	34·83	34·63	34·61	34·47	34·40	34·56

Later on when we are going to mention the single observation, we shall find, that the water influenced by the water from the polar streams, alters its extension in east—westerly direction very much, and now we may deduce from the tables, that these variations are not bound to the special seasons, but may occur at any time.

The observations in the east Icelandic polar stream are too few to allow a formation of means. Still it seems from the observations in 1903 and 1904, that the extension of that stream is very irregular, and mostly dependent on the formation of barometrical minima and their influence upon the water. We thus may conclude, that while a seasonal variation is found in the eastern part of the Atlantic, this is not to the same extent the case in the parts of the Atlantic, where the Atlantic water is influenced by the polar streams. In these parts we have considerable but merely occasional changes due to accidental circumstances. In the real polar streams themselves we probably should find seasonal variations, if a sufficient material of observation was at hand, but I am sorry to say, that our material is too small to be used for that purpose.

Now it is a question, what can be deduced from the seasonal variation found in the salinity in the eastern part of the Atlantic. The easiest and perhaps the most probable explanation of this periodical alteration would be, that the Gulfstream, on an average, has its greatest velocity or is most powerful in spring (April, May), while its minimum period occurs in autumn (September, October). This explanation, however, may be false and in my opinion more observations in lower latitudes are necessary to give a final answer to this question.

The Single Observations.

As has been shown in the preceeding chapter the variations in temperature and salinity of the surface water on the "Laura"-Route are exceedingly small when reckoned from year to year. They are so small, that their existence could not be proved with any certainty. During the single year both temperature and salinity are undergoing periodical variations. These variations in salinity are small too, but still great enough to be shown with certainty. When now we are going to discuss the single observations, it follows as a matter of course, only to take such observations in consideration, which are lying out of the areas used by the compiling of the means, or such observations, whose deviations from the means found are greater than the mean deviations given in Table 1.

The Observations in 1900.

Pl. II—V.

It is to be seen from the map on Pl. I, that the greatest values of temperature and salinities are found in the Faroe—Shetland Channel just above the deepest part of the channel, due to the fact, that the Atlantic current here is running with its greatest mean velocity in NE direction. We have also pointed out, that comparatively great deviations from the mean values of salinity are occurring here due to the influence of the North Sea water, the coast water and water from the Norwegian Sea and the East Icelandic Polar Current.

From the observations printed on the maps following Plate I is to be seen, that the eastern branch of the Atlantic current (the branch going between the Shetland-islands and the Faroes) in the time from the 17th of March to 14th of April 1900, Pl. II is showing exceptional high salinities f. inst. 35·48 ‰ 35·51 ‰, the water with the highest salinity also has the highest temperatures but the temperatures are low compared with the mean for that voyage, as it is given in Table 3. The low temperatures are partly due to the neigbourhood of the East Icelandic Polar current, f. inst. temperatures as low as 3°·4 south of the Faroes. Also between the Faroes and Iceland the temperatures are low, and a very rapid variation is to be seen W of the Faroes. Between 10° and 11° W we thus have a temperature of 8° the 23th of March and 6 days later a temperature of 4°·5 at almost the same place.

The observations on the route N of Scotland to Greenland between 59° N and 61° N have the common character with the 35·00 ‰ isohaline at about 33° W.

The 19th of April—18th of May 1900, Pl. II. The temperatures in the Faroe—Shetland channel now have acquired their ordinary values except a single one close to Shetland. Between the Faroes and the southern part of Iceland the temperatures as well as the salinities are low. On the Greenland route is found as low salinities as 35·11 ‰ on 23° W, which is much lower than on 22° W just S of Iceland.

The 1st of June—25th of June 1900, Pl. III. The salinities have their common values even on the Greenland route. The temperatures are high, at a single place 2°·7 higher than usual.

The 15th of July—12th of August 1900, Pl. III. Temperatures and salinities on the Iceland-route as common. In the Faroe-Shetland channel the salinities are low and on the Greenland-route is found a salinity of 34·92 ‰ at about 20° W. This low salinity can only be due to the East-Greenland Polar current and thus is to be seen how far this water can extend to the east in the open Atlantic.

The 19th of August—22nd of September 1900, Pl. IV. Salinities in the Faroe-Shetland channel and on the Iceland routes as generally. The temperatures high, at single places exceeding the mean value with more than 2°·5. On the routes from Scotland to S of Greenland and from S of Iceland to Angmagsalik on the east coast of Greenland rather low salinities are found. We, therefore, may conclude, that the main part of the Irminger current at that time was formed by water from the western part of the Atlantic current and not from water coming from the south of Iceland.

That the water close to the south coast of Iceland as a costal stream may follow the west coast of Iceland in a northerly direction is very probable but quite another case.

The 30th of September—1st of November 1900, Pl. IV. Both in the Faroe-Shetland channel and on the Faroe-Iceland route salinities rather high, and low temperatures.

The 20th of November—11th of December 1900, Pl. V. Temperatures rather low at all places. The east Icelandic polar current is seen to touch the route NW of the Faroes producing a salinity of 34·99 ‰ with corresponding low temperature.

Taking all the observations in 1900 together we see, that the temperatures have now been higher than, and now below the means. In most cases they have been rather low. The water in the Faroe-Shetland channel has changed rapidly and in the open Atlantic too considerable changes have taken place, because the Greenland-waters have made their influence strongly felt in May and especially in the end of July.

The Observations in 1901.

Pl. V—VII.

The 20th of January—17th of February 1901, Pl. V. Some very high salinities occur in the Faroe-Shetland channel followed by very high temperatures (above 35·50 ‰ and 8°·0). The salinities on the Faroe-Iceland route are a little too high and the temperatures very variable all over.

The 10th of March—2nd of May 1901, Pl. VI. In the Faroe-Shetland channel, on the Faroe-Iceland route and on the Scotland Greenland route are found salinities of the common value, while the temperatures are very variable, now too high and now too low.

The 17th of May—31st of July 1901, Pl. VI. In the Faroe Shetland channel we only find salinities of the common value; some very high temperatures occur. On the Scotland Greenland route a slow decrease in the salinity is to be found from May—June to July.

The 9th of August—5th of October 1901, Pl. VII. On the route running from N of Scotland to Angmagsalik very low salinities have been found, f. inst. south of the Faroe-Iceland ridge, at a considerable distance south of it as low a salinity as 35·03 ‰ and from Reykjanæs to Angmagsalik not a single salinity above 35·00 ‰ has been found. Also on the route N of Scotland—S of Greenland uncommonly low salinities are found, f. inst. 34·96 ‰ on about 56° N and 30° W.

The Observations in 1902.

Pl. VII—VIII.

The 22nd of March—7th of August 1902, Pl. VII. On the route N of Scotland to S of Greenland we find the common values of salinity except in August at which time the salinities in the open Atlantic are very low.

The 2nd of October—31st of October 1902, Pl. VIII. In the Faroe-Shetland channel the influence of the east-Iceland polar current is strongly felt. It produces salinities below 35·00 ‰ just above the deepest part of the channel. On the route from the Faroes to S of Iceland also low salinities are found but they are combined with temperatures higher than the means.

The 19th of November—11th of December 1902, Pl. VIII. In the Faroe-Shetland channel the influence of the east Icelandic polar current is strongly felt again. Above the deepest part we find a salinity 34·87 ‰ followed by temperatures lower than the means. On the Faroe-Iceland route the salinities are also lower than usual but as in October the temperatures here are all too high.

The general result of the observations in 1902 will thus be that from August to the end of the year we find unusual low salinities in the Faroe-Shetland channel and probably also in the open Atlantic. It thus seems as if the Atlantic current has to that time fallen off in strength and given more room to the polar currents.

The Observations in 1903.

Pl. IX—XIV.

The observations of temperature and salinity have mostly their common value or are a little below that. On the route N of Scotland to S of Greenland we observe some changes, f. inst. an increase in the salinity is taking place from the middle to the end of May. In June and July and August most of the temperatures are somewhat below the means. On the route from S of Iceland to Angmagsalik we find higher values for the salinities than in the two previous years (between 35·10 and 35·20 ‰).

The general result of the observations in 1903 will thus be, that as well the temperatures as the salinities on most of the voyages have been a little below the means. The east Icelandic polar current has undergone considerable changes. As will be seen from the maps, we have observations on the Faroe—East Iceland route in every month from March to November. From the 8th of March to the 11th of July the route was mainly lying in Atlantic water, only crossing the coastal part of the polar current near Iceland. On August 15th the situation had changed as the route for the greatest part is now influenced by the polar water giving salinities only little above or even below 35·00 ‰ from Iceland to ca. 100 miles

NW of the Faroes. The polar current is thus making its influence felt from August to the middle of November, at which time (Nov. 18th) the Atlantic water again begins to predominate.

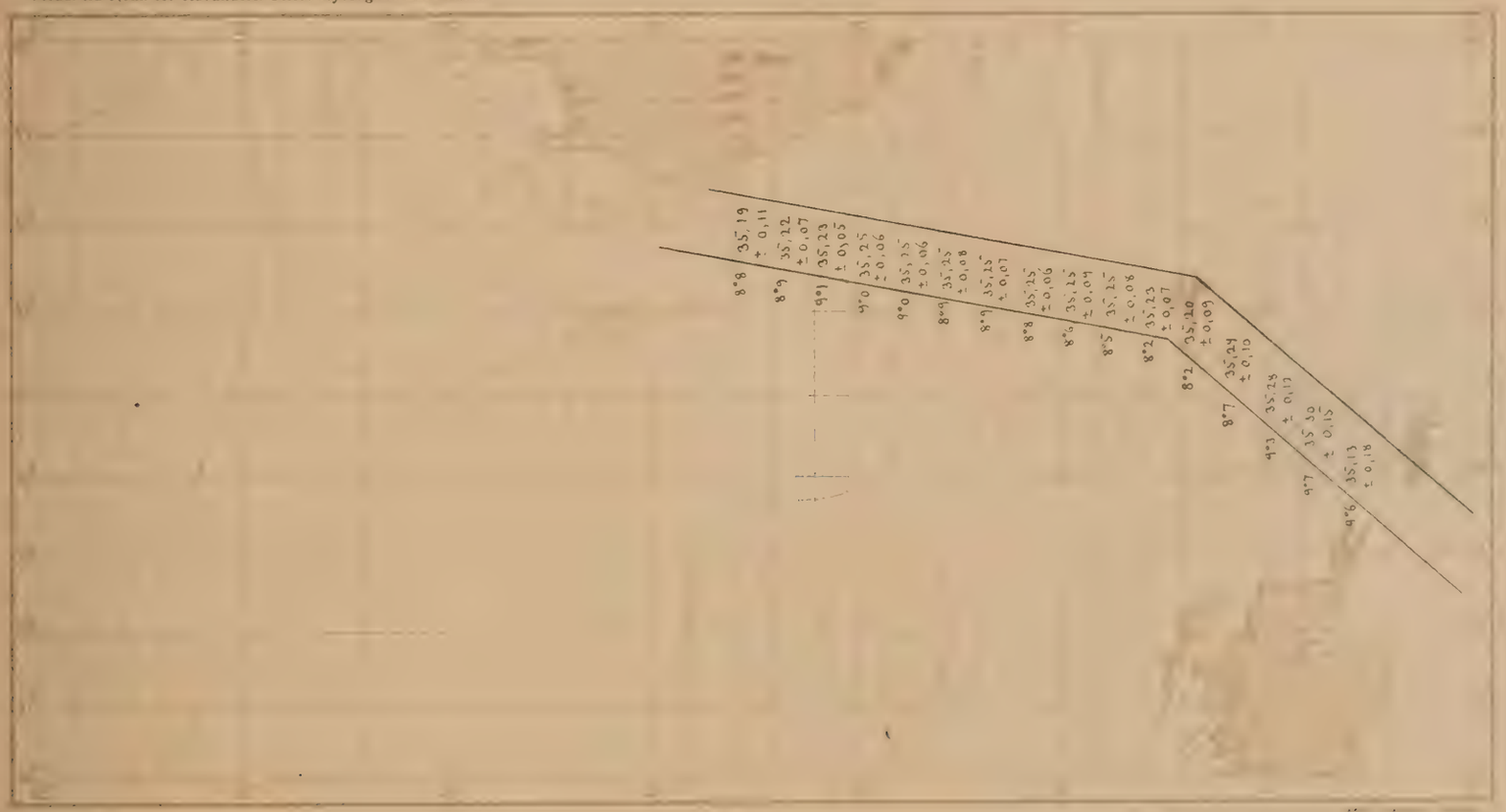
The Observations in 1904.

Pl. XIV—XXI.

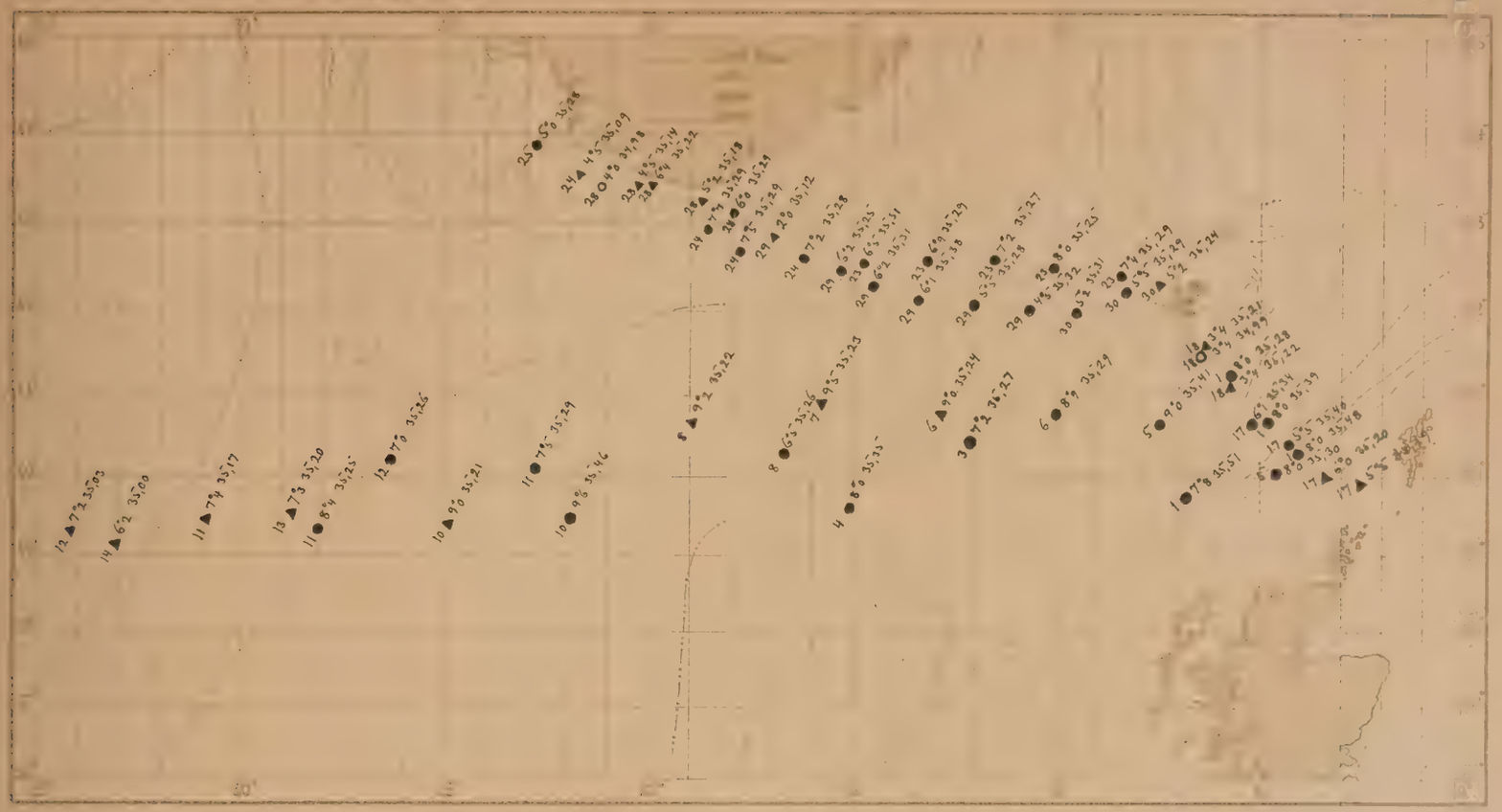
The temperatures and salinities are mostly of the common value. In April and May some very low salinities are found on the route N of Scotland to S of Greenland, f. inst. 35·12 ‰ on 15° W and 34·94 ‰ on 21° W. Some of the observations on this route are probably wrong, but still it seems as if heavy gales have been able to mix the polar water up in the Atlantic so as to form spots with high salinities in surrounding water of low salinity and vice versa. In May, June, and July most of the temperatures and salinities are a little below the means. In August we find very high salinities on the route S of Iceland to Angmagsalik (35·23—35·41 ‰). These values are so high that they cannot be regarded as completely trustworthy especially as in continuation of this route as high salinities as 35·61 and 35·71 ‰ have been found between Scotland and Iceland. In October most of the temperatures show values above the means.

With regard to the Faroe—east Iceland route we found that the Atlantic water made itself more felt again in the end of 1903. The same is the case in January and February 1904. Also in the following months until June 14th the Atlantic water is predominating but then in the course of 4 days an alteration takes place and on the 18th of June the polar water is predominating. In the following months we have rapid variations but the influence of the polar current is felt all the time till the beginning of December, at which time the Atlantic water again predominates as the polar current is limited to the neighbourhood of Iceland.

Mean Values of Temperature and Salinity of the Surface-water and Mean Deviations of the Salinity. 1897–1904.



Temperature and Salinity of the Surface-water March 17. – April 14. 1900.

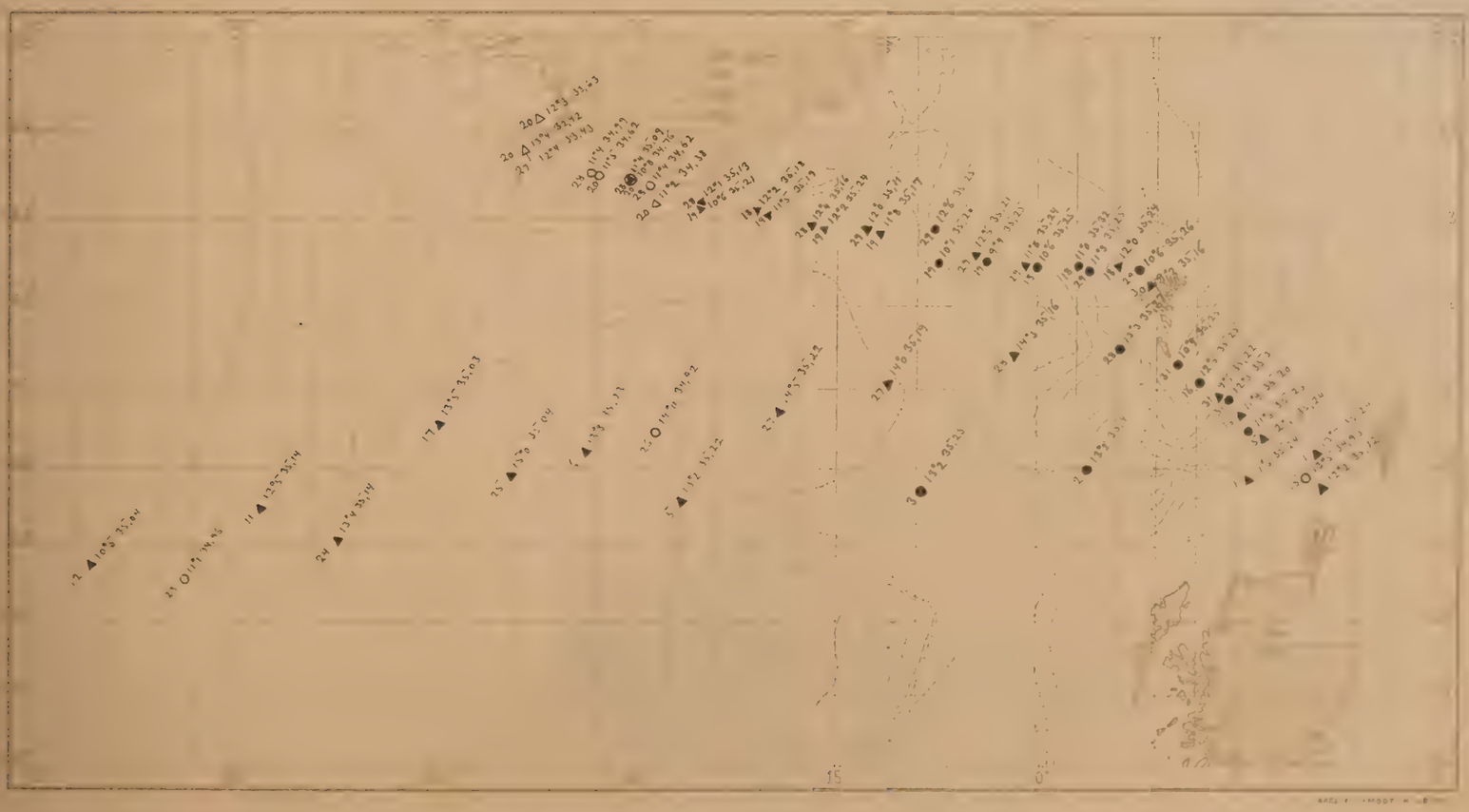


Temperature and Salinity of the Surface-water April 19. – May 18. 1900.

At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

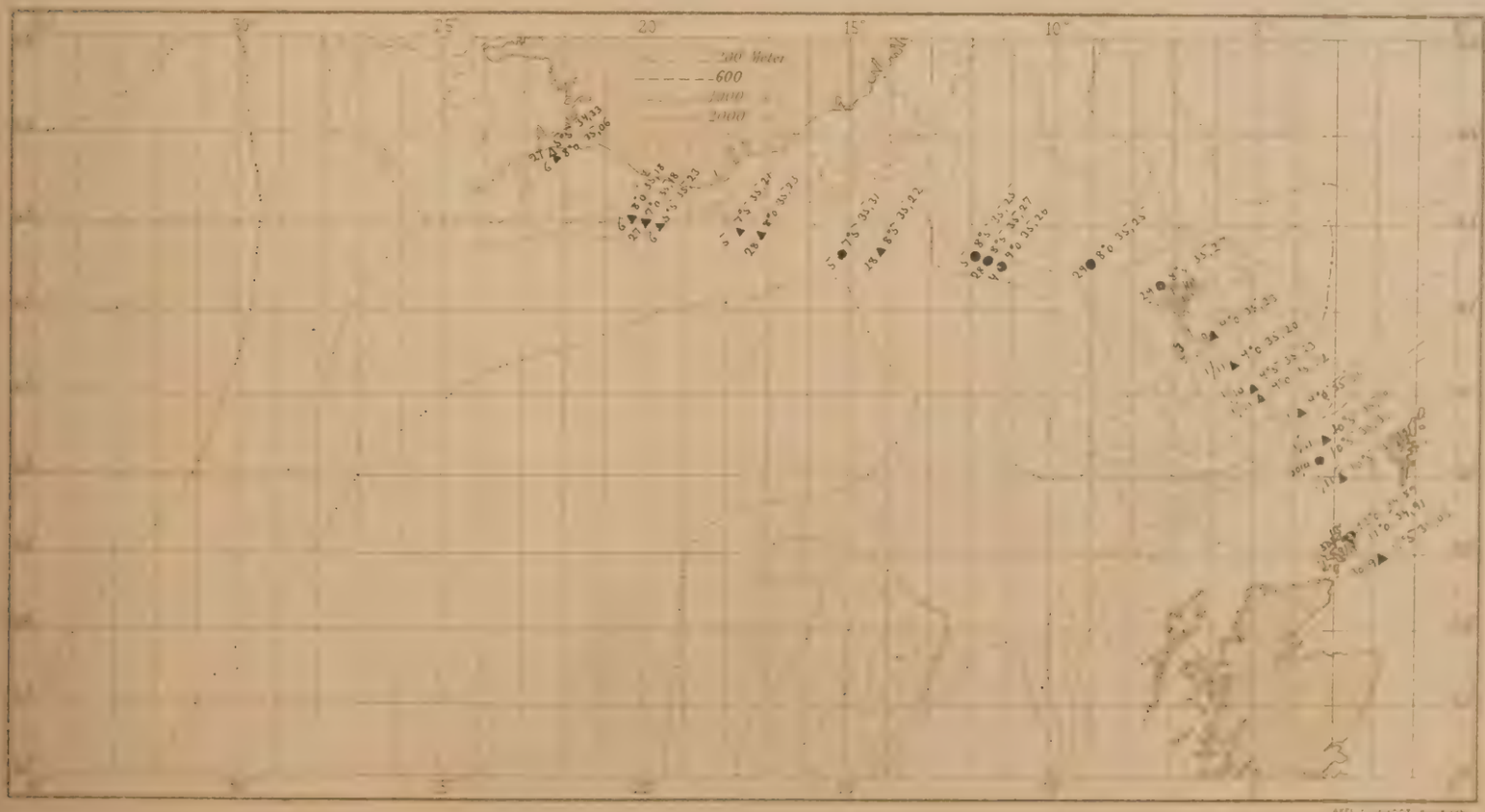
Temperature and Salinity of the Surface-water June 1. – 25. 1900.

Temperature and Salinity of the Surface-water July 15. – Aug. 12. 1900.

At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water Aug. 19.—Sept. 22. 1900.

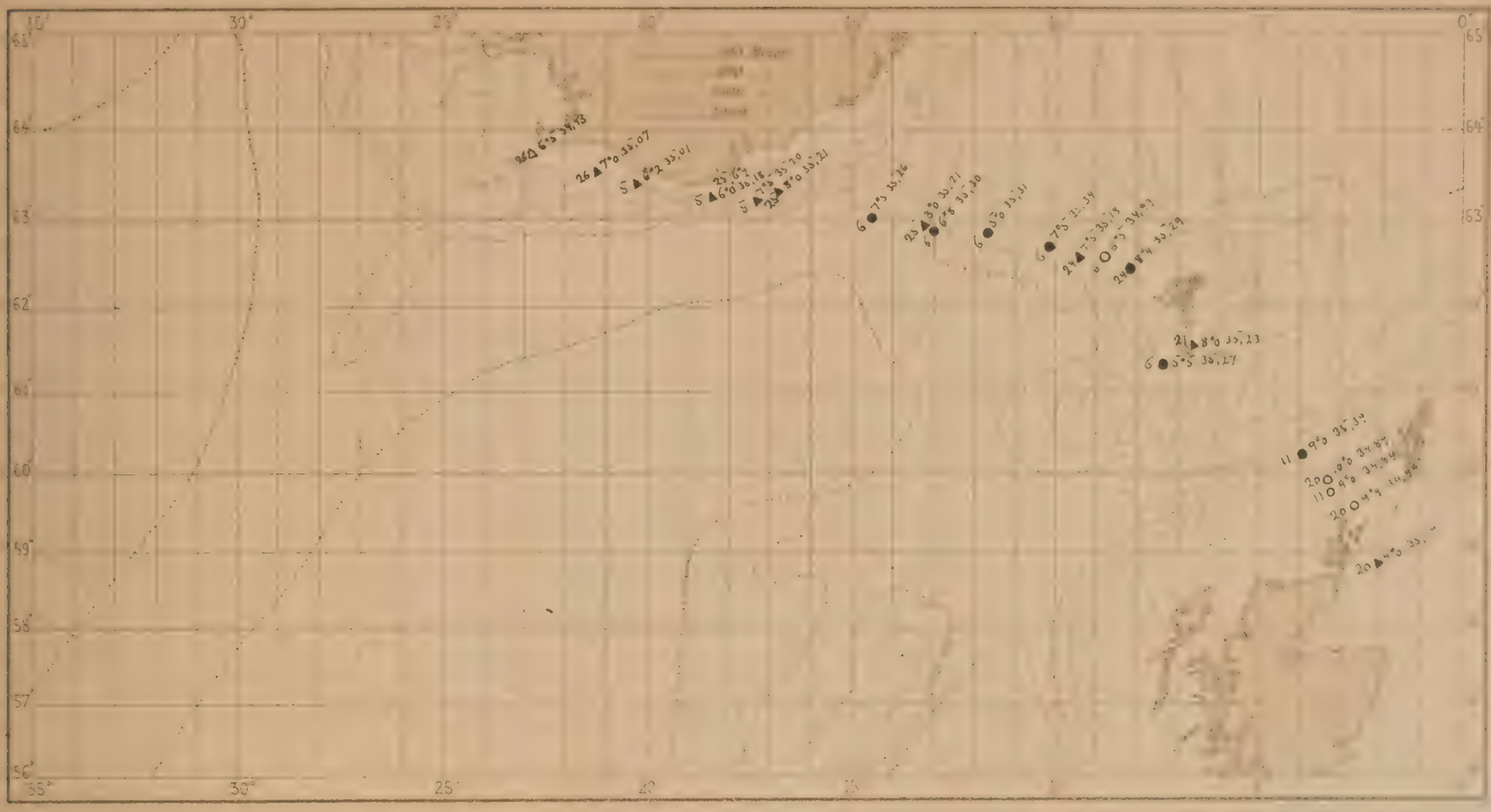
Temperature and Salinity of the Surface-water Sept. 30.—Nov. 1. 1900.



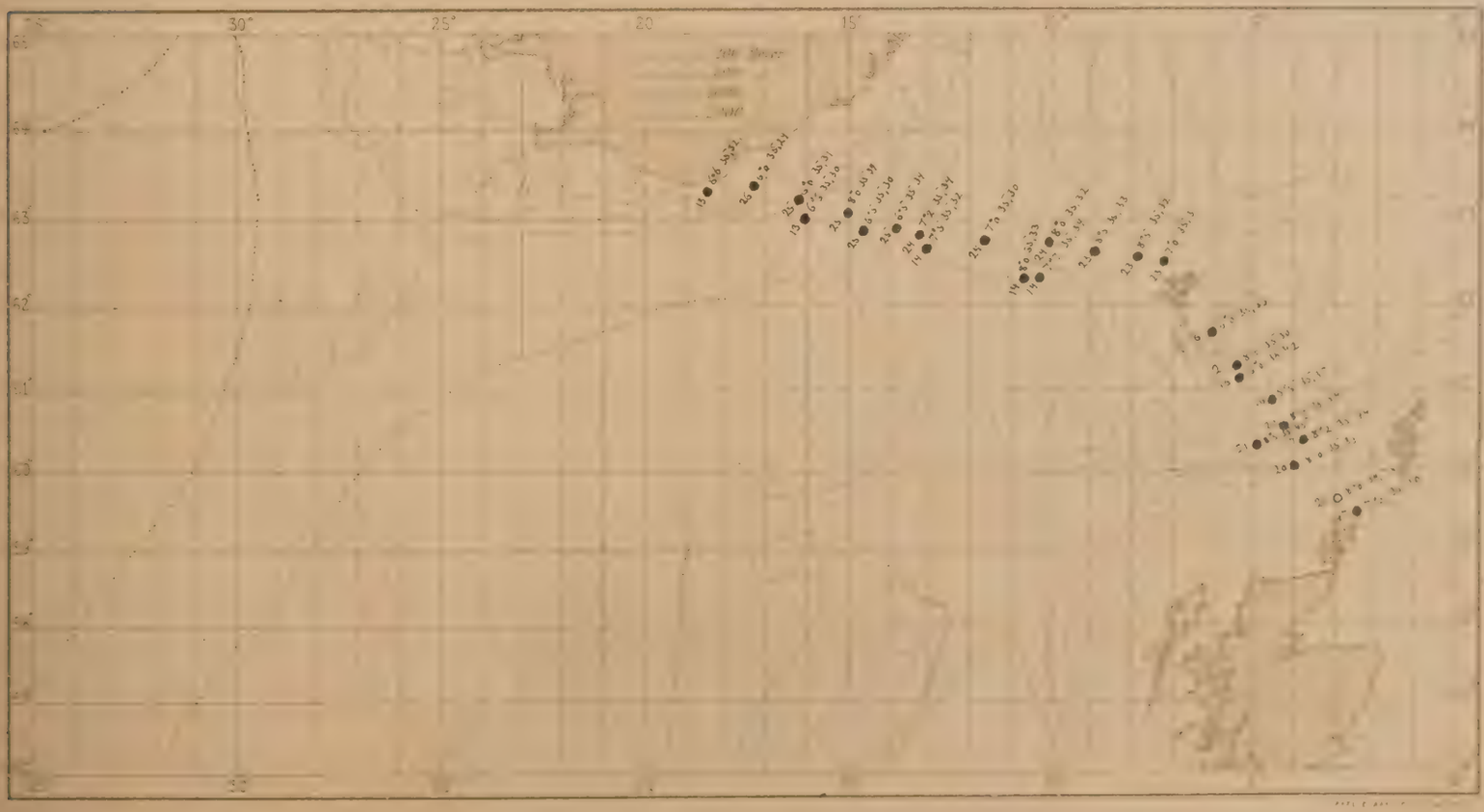
At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water Nov. 20.—Dec. 11. 1900.



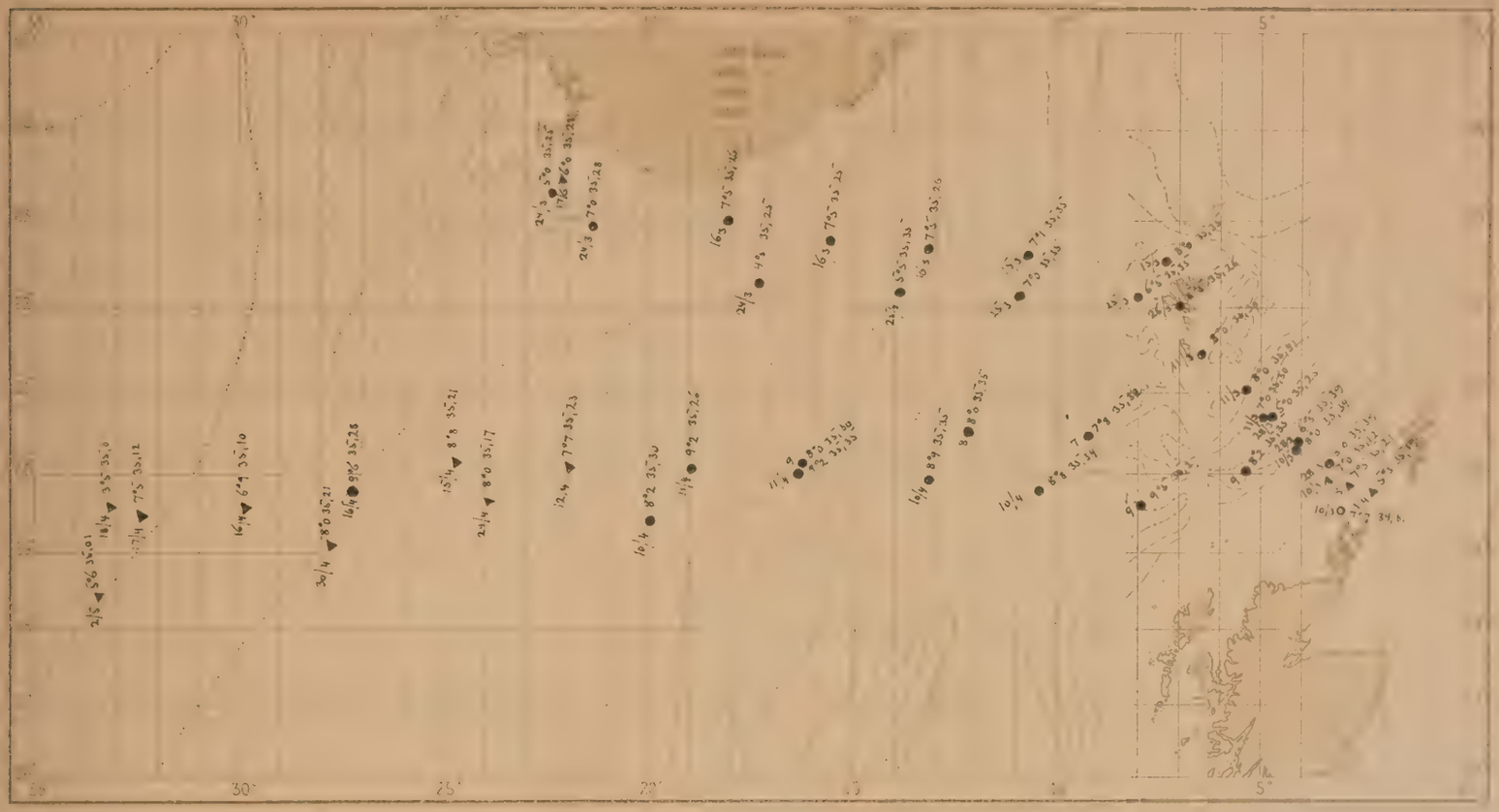
Temperature and Salinity of the Surface-water Jan. 20.—Febr. 17. 1901.



At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water March 10.—May 2. 1901.

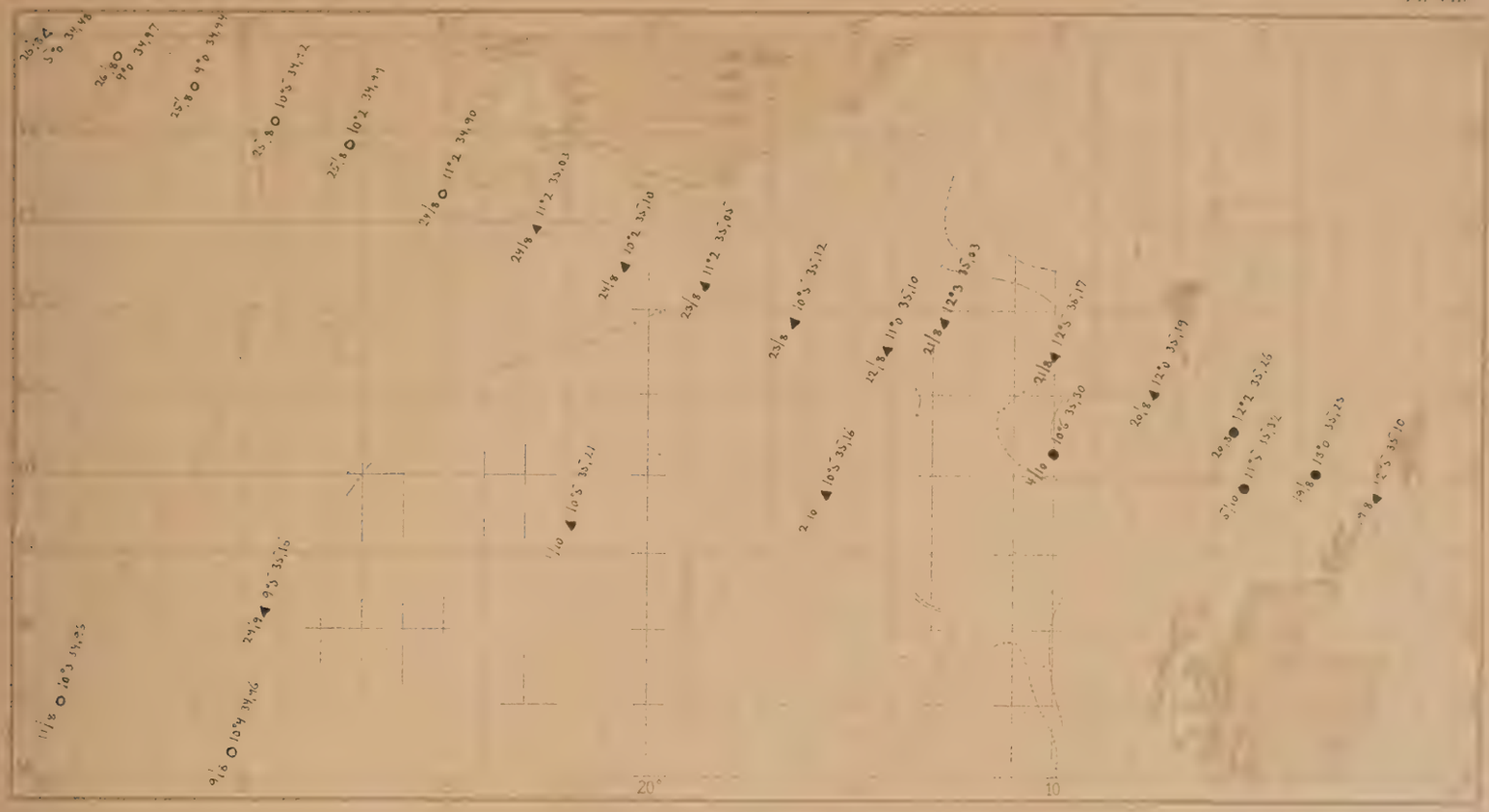


Temperature and Salinity of the Surface-water May 17.—July 31. 1901.

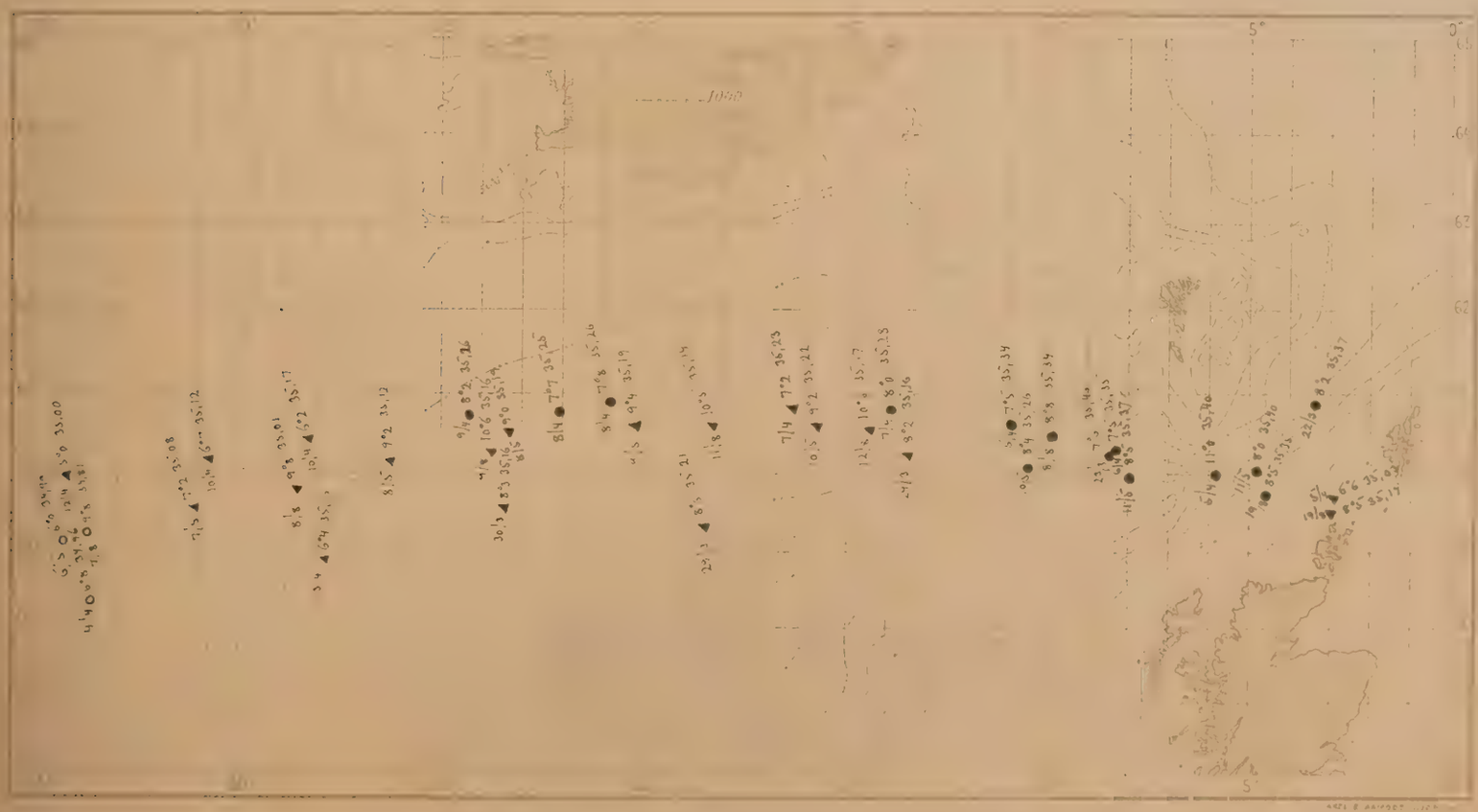
At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water Aug. 9. – Okt. 5. 1901.



Temperature and Salinity of the Surface-water March 22. – Aug. 7. 1902.

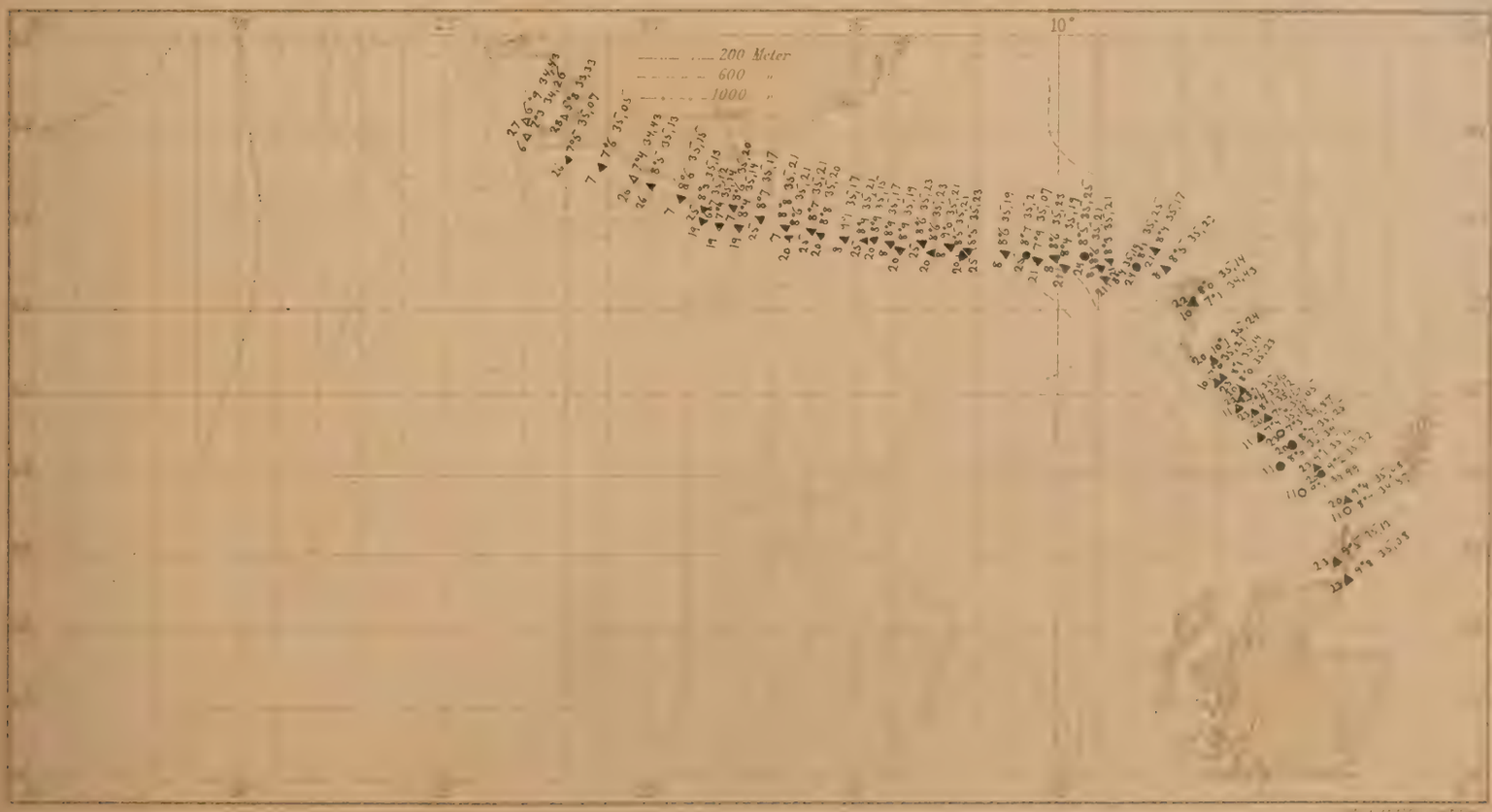


At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water Okt. 2.–31. 1902.

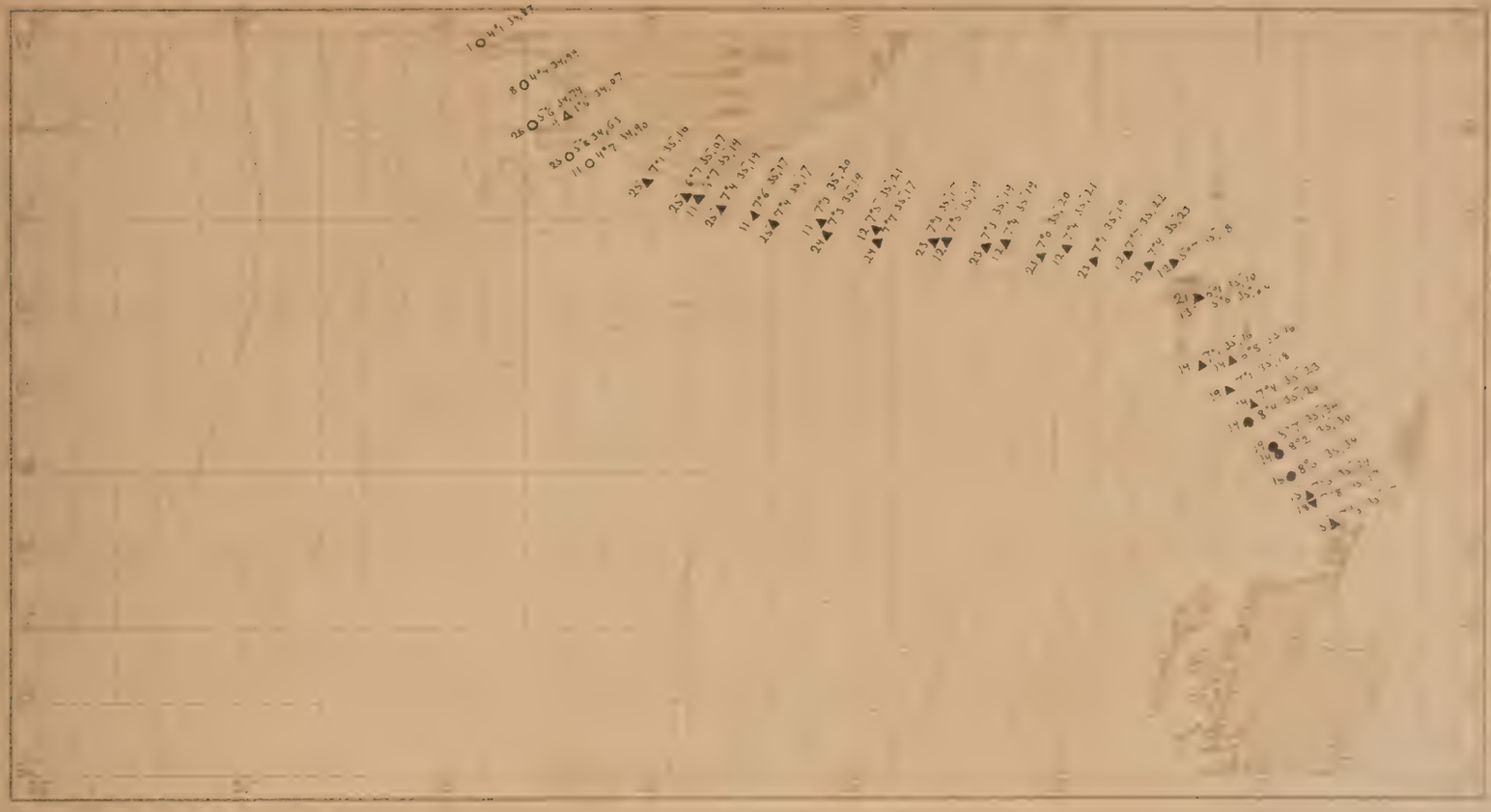
Temperature and Salinity of the Surface-water Nov. 19.–Dec. 11. 1902.



At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water Jan. 18.—Febr. 15. 1903.



Temperature and Salinity of the Surface-water March 7.—April 5. 1903.

At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water April 9.—30. 1903.

Temperature and Salinity of the Surface-water May 1.—31. 1903.

At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water June 1.—July 3. 1903.

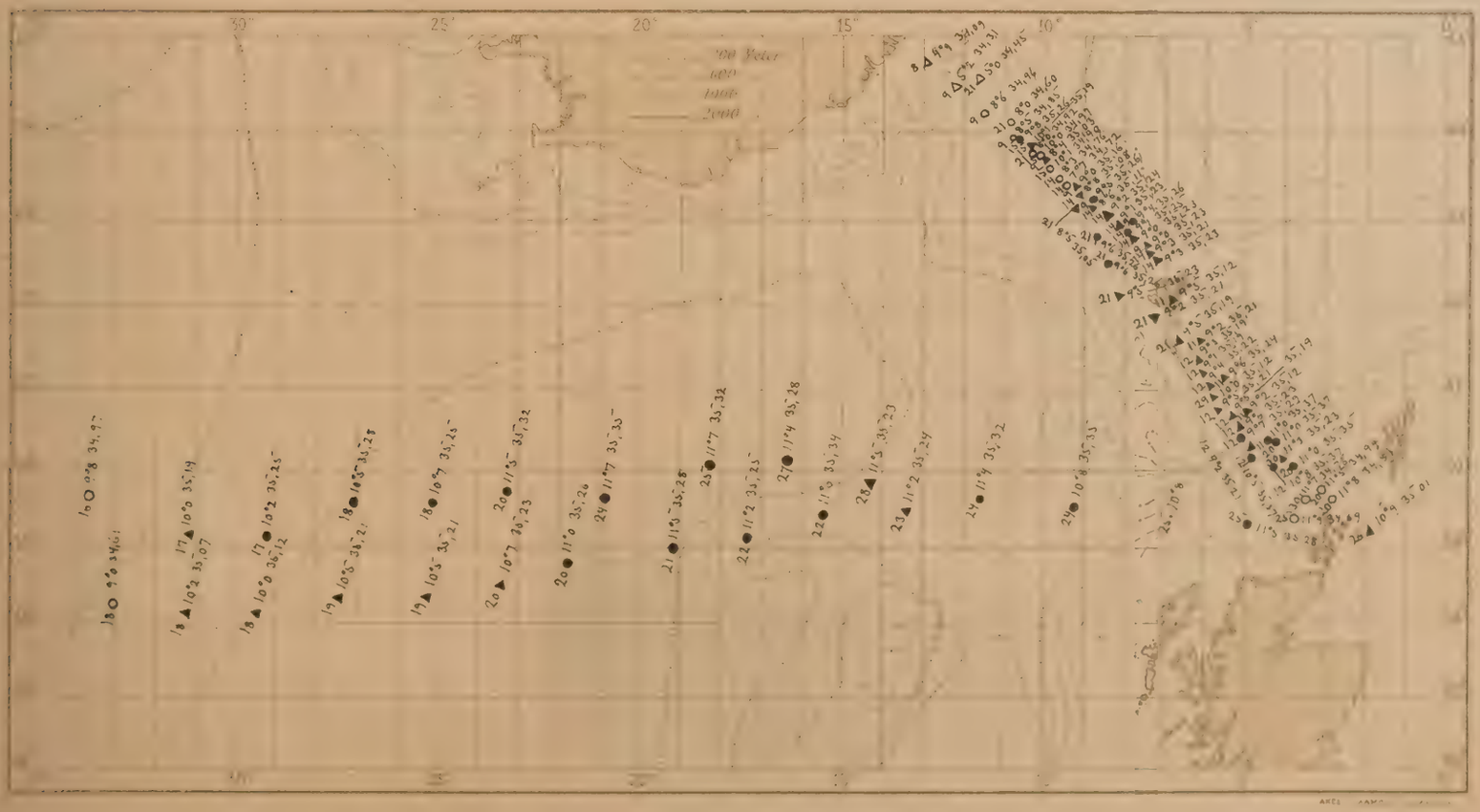
Temperature and Salinity of the Surface-water July 4.—27. 1903.

At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water July 28.—Aug. 30. 1903.

Temperature and Salinity of the Surface-water Sept. 8.—30. 1903.



At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

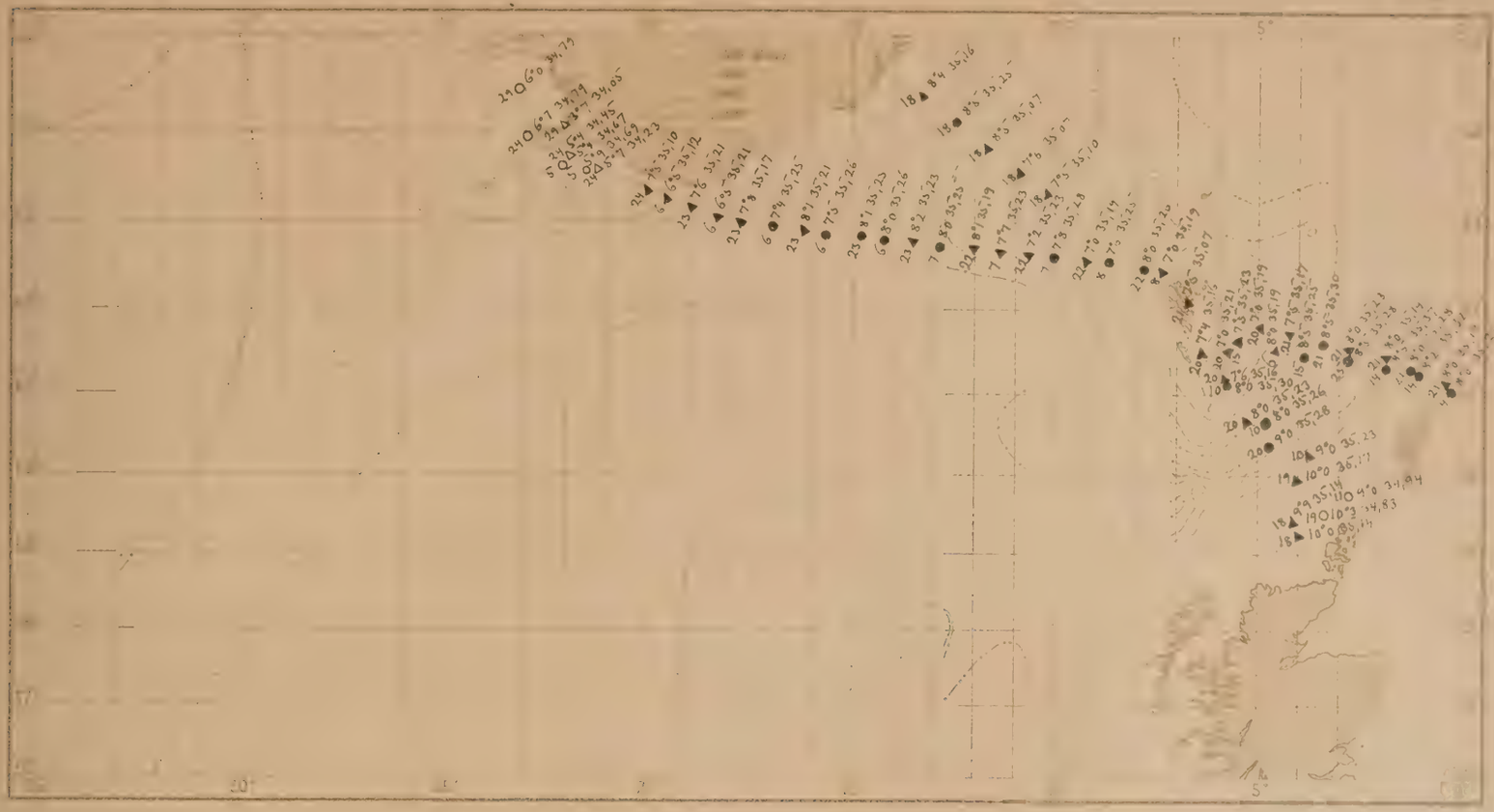
Temperature and Salinity of the Surface-water Okt. 1.—28. 1903.

Temperature and Salinity of the Surface-water Okt. 29.—Nov. 17. 1903.

At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water Nov. 18. – Dec. 15. 1903.



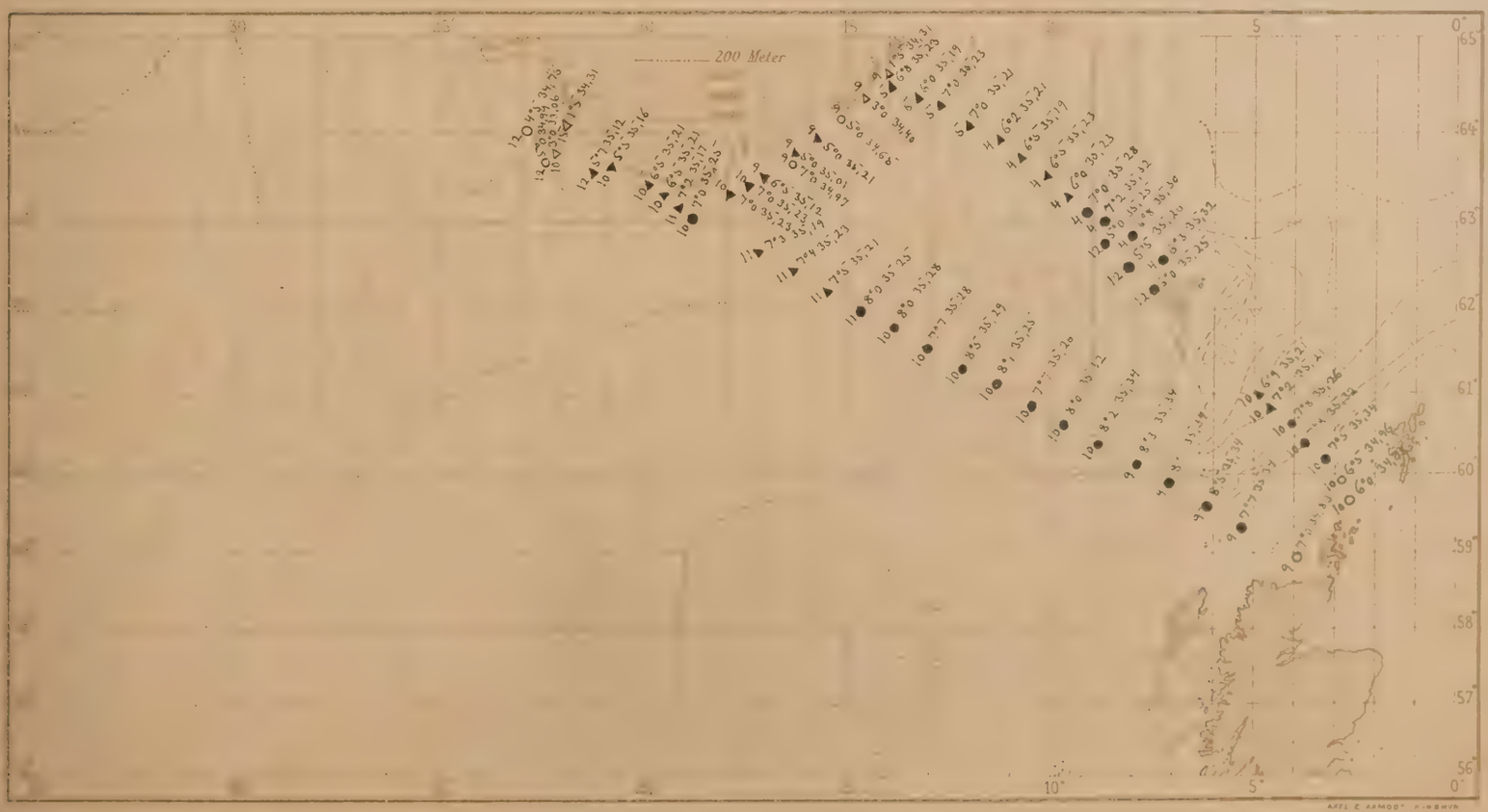
Temperature and Salinity of the Surface-water Jan. 6. – Febr. 12. 1904.

At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water Febr. 13.—March 3. 1904.

Temperature and Salinity of the Surface-water March 4.—15. 1904.



At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water March 18.—April 13. 1904.

Temperature and Salinity of the Surface-water April 14.—May 6. 1904.

At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water May 14.—June 13. 1904.

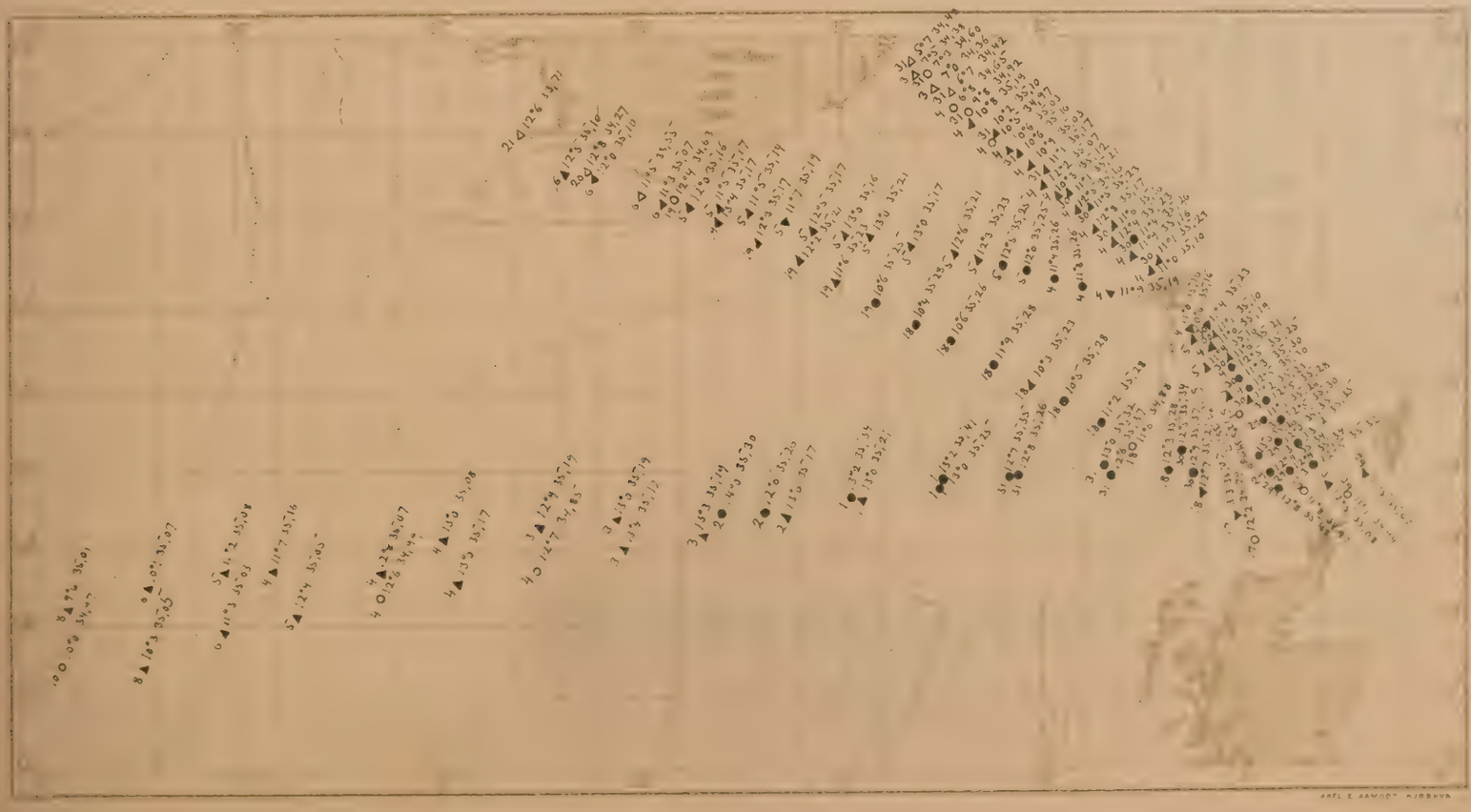
Temperature and Salinity of the Surface-water June 14.—24. 1904.

At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water July 9.—24. 1904.

Temperature and Salinity of the Surface-water July 29.—Aug. 21. 1904.

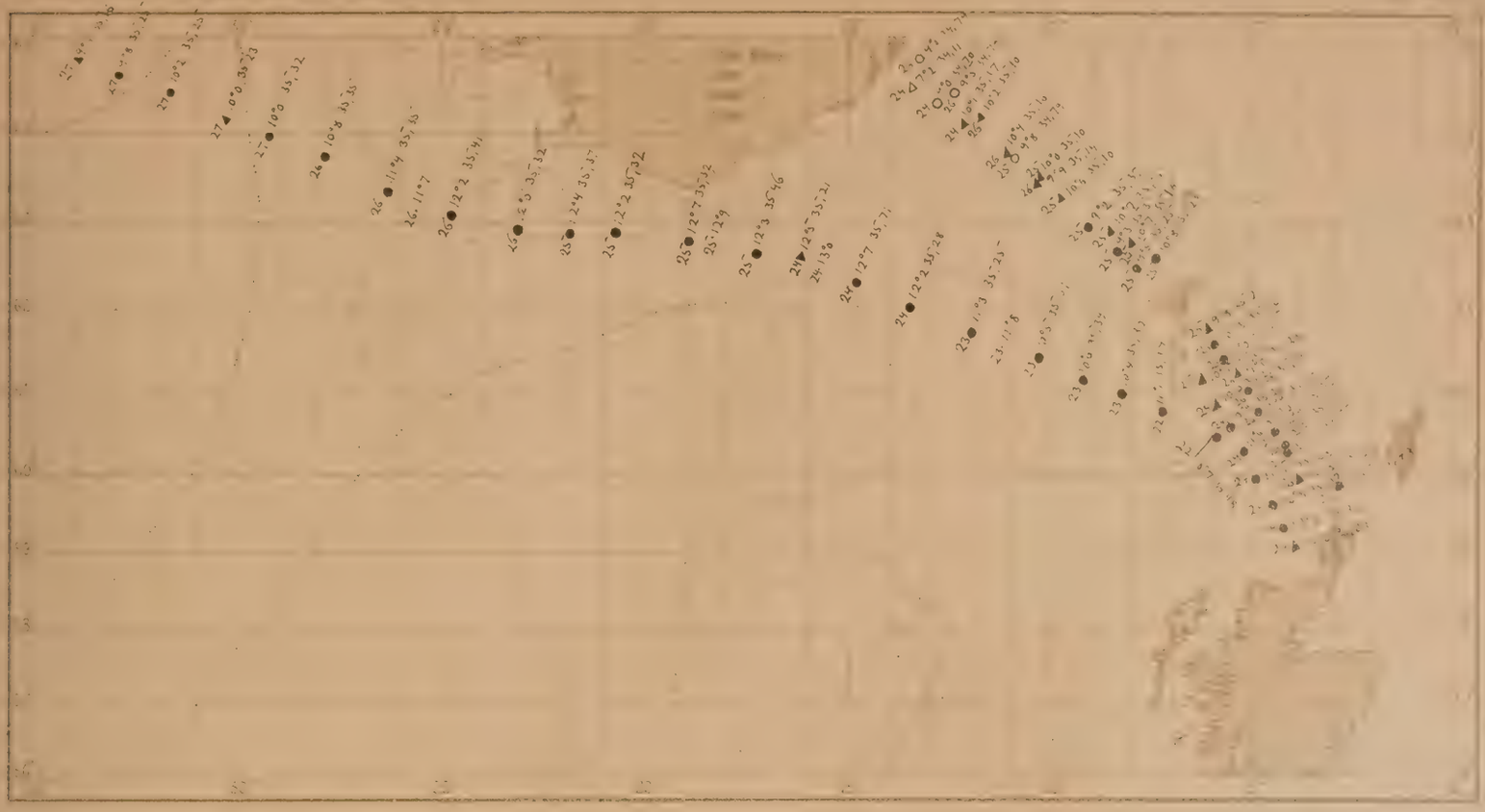


At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water Aug. 22.—27. 1904.

Medd. fra Kom. for Havunders. Serie: Hydrografi Bd. I Nr. 6.

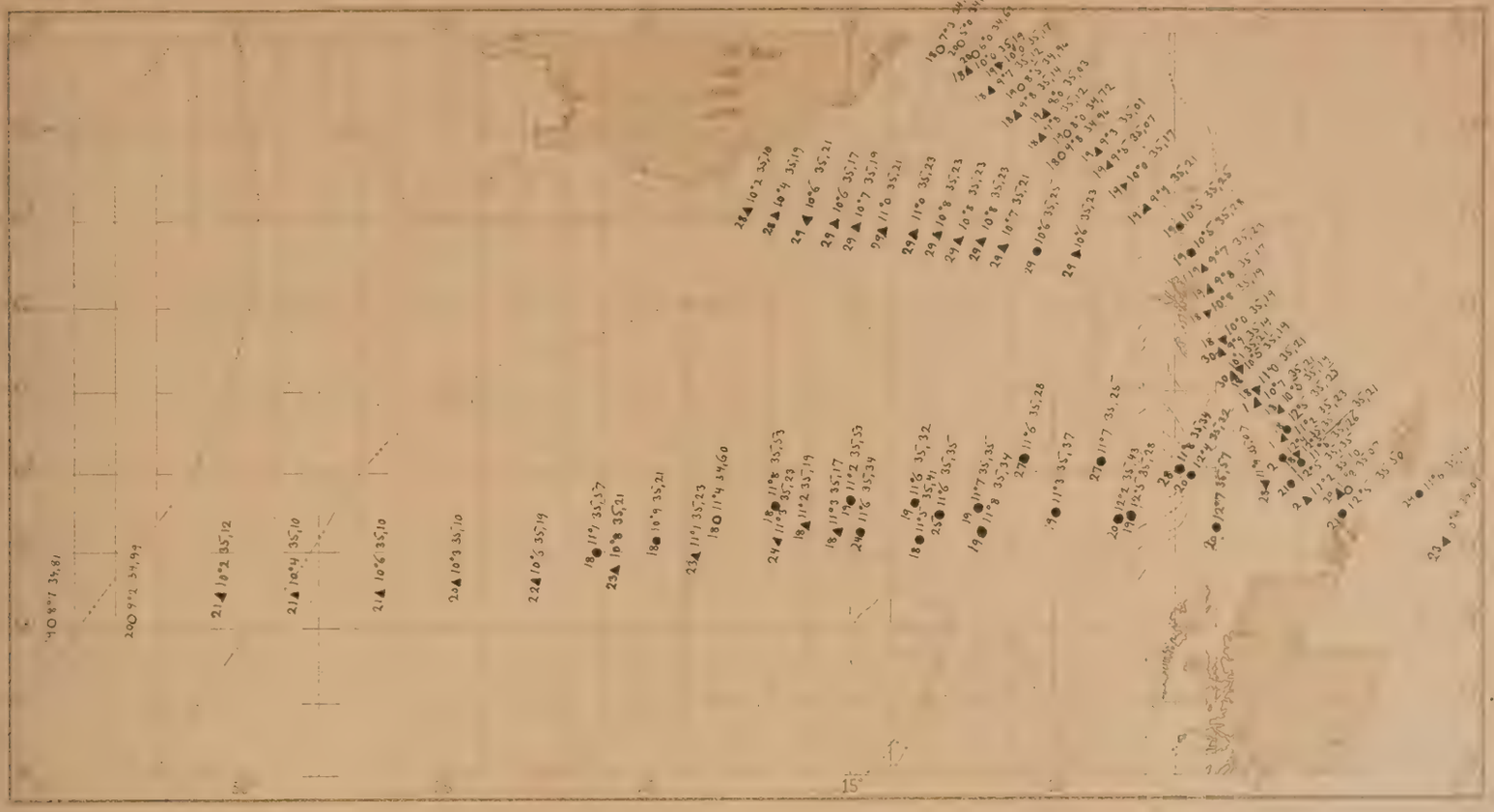


Temperature and Salinity of the Surface-water Aug. 28.—Sept. 17. 1904.

At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water Sept. 18. – Okt. 2. 1904.

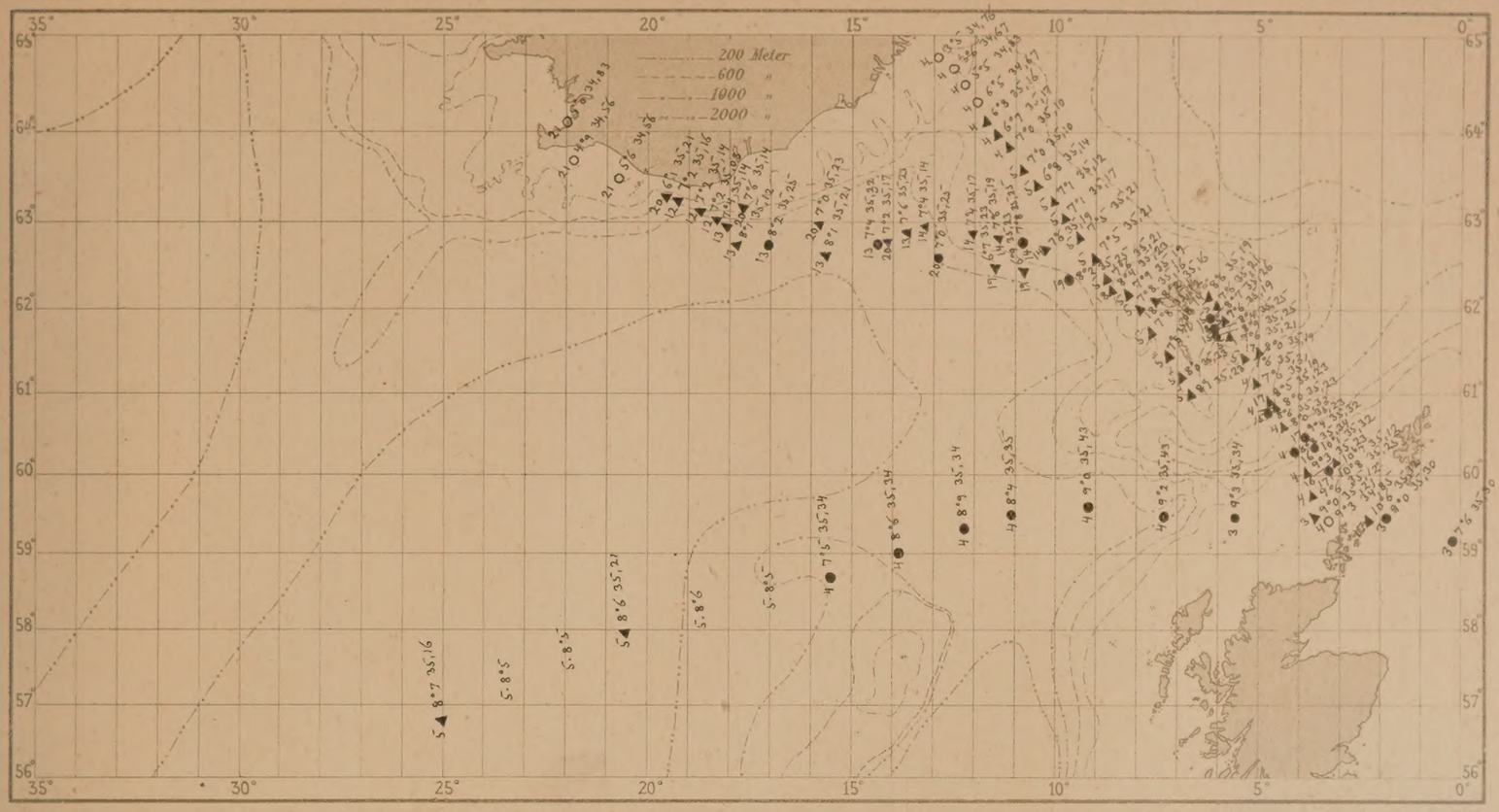


Temperature and Salinity of the Surface-water Okt. 3. – Nov. 2. 1904.

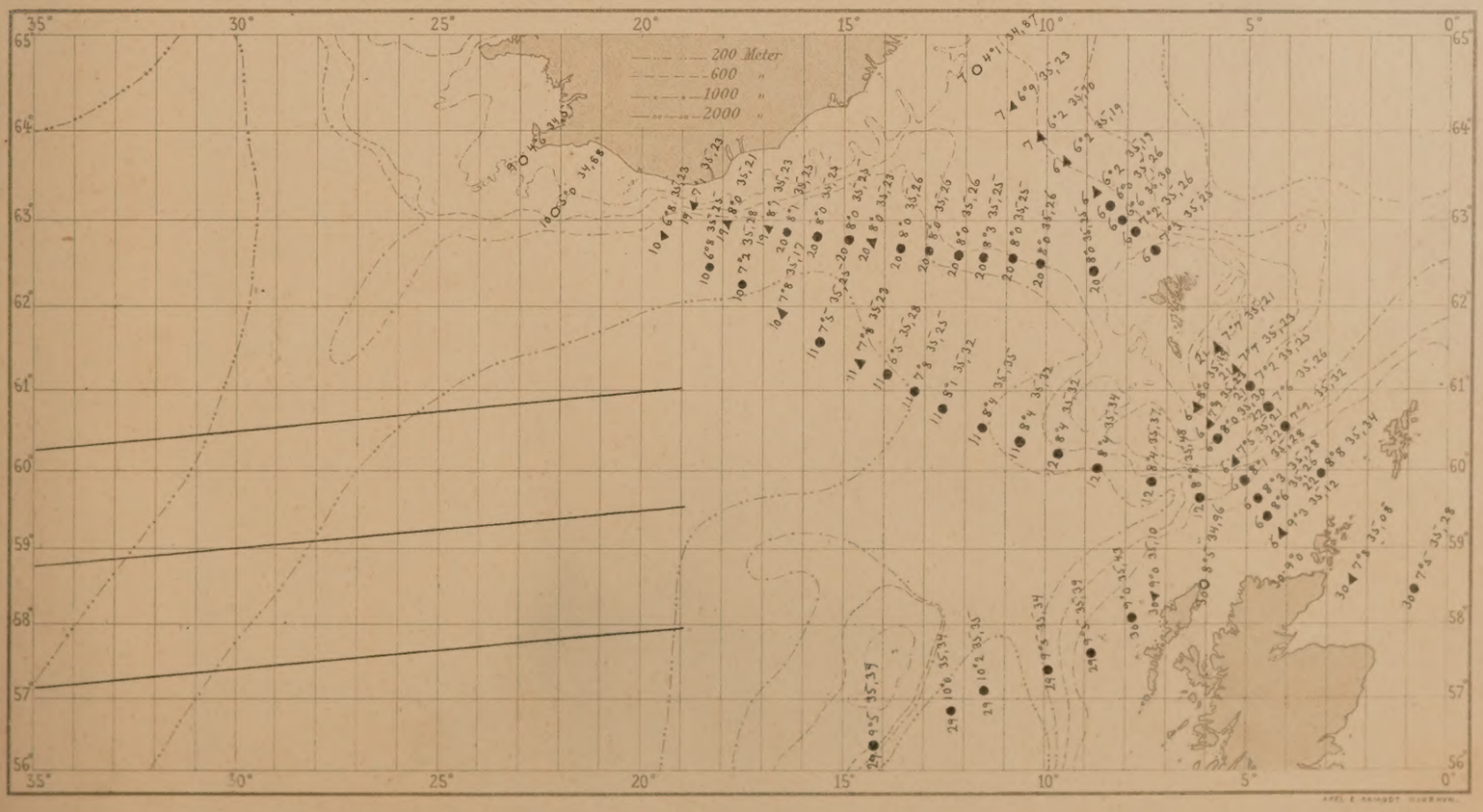
At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.

Temperature and Salinity of the Surface-water Nov. 12.–Dec. 5. 1904.



Temperature and Salinity of the Surface-water Dec. 6.–30. 1904.



At each place is given the date of the observation, the temperature centrigrade and the salinity ‰.

● Salinity greater than 35,25. ▲ Salinity between 35,00 and 35,25. ○ Salinity between 34,50 and 35,00. △ Salinity less than 34,50.